Attorney Docket No. 5308-376 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re: Meadows
Serial No.: 10/734,398
Filed: December 12, 2003
For: NON-UNIFORM GATE PITCH SEMICONDUCTOR DEVICES

Confirmation No. 1180
Group Art Unit: 2814
Examiner: Ahn D. Mai

Supplemental Declaration of Ronald Meadows Under 37 C.F.R. § 1.131

Sir:

I, Ronald C. Meadows, hereby declare as follows:

1. I am the named inventor on U.S. Patent Application Serial No. 10/734,398 entitled "Non-Uniform Gate Pitch Semiconductor Devices" (*hereinafter*, "the '398 application"), filed December 12, 2003.

2. I executed a Declaration in the above-captioned case on February 28, 2006. The Declaration of February 28, 2006 is incorporated herein by reference.

3. From November 8, 1999 to May 14, 2005, I was employed as a Design Engineer at Cree, Inc. ("Cree"), the assignee of the '398 application, located in Durham, N.C. My job responsibilities included the design of wide bandgap RF semiconductor devices.

4. I invented the subject matter of the '398 application. In particular, I conceived and reduced to practice the subject matter of the '398 application in the United States prior to November 2, 2001. Diligence was exercised from prior to November 2, 2001 to the actual reduction to practice of the subject matter of the '398 application. Furthermore, diligence was exercised from prior to November 2, 2001 until the filing of the '398 application.

5. As stated in my Declaration of February 28, 2006, prior to November 2, 2001, I designed and caused to be fabricated 30W SiC MESFET devices ("30W VGS devices") having a non-uniform gate structure (referred to as Variable Gate Spacing, or VGS) having a gate pitch as described in the Declaration of February 28, 2006, in an effort to create transistors having lower peak junction temperatures and/or more uniform junction temperatures during RF operation. Each of the 30W VGS devices included 36 unit cells connected in parallel. Each unit cell included a source region and a drain region. The 30W VGS devices each included a plurality of gate fingers electrically connected in parallel.

6. Prior to fabricating the 30W VGS devices, a thermal simulation of the 30W VGS devices was performed at Cree using Harvard Thermal, Inc. TAS thermal modeling software. The results of the thermal simulation, which are shown in Figure 3 of the '398 application, predicted lower peak junction temperatures and more uniform junction temperatures during RF operation for the 30W VGS devices.

7. I also designed and caused to be fabricated 60W SiC MESFET devices ("60W VGS devices") having a non-uniform gate pitch design as described in the Declaration of February 28, 2006. The 60W VGS devices were designed and fabricated prior to November 2, 2001.

8. A lot of 30W VGS devices was tested for both DC and RF performance. DC testing of the 30W VGS devices was completed by at least September 20, 2000, and RF testing of the 30W VGS devices was completed by at least October 3, 2000.

9. Redacted copies of pages from my laboratory notebook relating to the lot of 30W VGS devices are attached hereto as Exhibit A. Each of the pages in Exhibit A references VGS devices from Lot 1801. The dates on the pages in Exhibit A are blacked out. However, each of the dates is prior to October 3, 2000.

10. A copy of the RF test results for the 30W VGS devices is attached hereto as Exhibit B. The RF test results shown in Exhibit B showed significant improvements in peak output power over similar devices having a uniform gate pitch. These improvements were attributed to the improved thermal performance of the devices, as predicted by the thermal simulation results described above.

11. Another lot of 30W VGS devices (Lot 1802) was fabricated shortly thereafter. Fabrication of the devices of Lot 1802 was completed by at least January 3, 2001. DC test data was taken on the devices of Lot 1802. Some of the results of DC testing of the devices of Lot 1802 are attached hereto as Exhibit C.

12. Yet another lot of 30W VGS devices (Lot 1805) was fabricated shortly thereafter. Fabrication of the devices of Lot 1805 was completed by at least February 7, 2001. DC test data was taken on the devices of Lot 1805. Some of the results of DC testing of the devices of Lot 1805 are attached hereto as Exhibit D.

13. Continuing with the development and testing of VGS devices, another lot of 30W VGS devices (Lot 1807) was fabricated shortly after completion of Lot 1805. Fabrication of the devices of Lot 1807 was completed by at least March 2, 2001. DC test data was taken on the devices of Lot 1807. Some of the results of DC testing of the devices of Lot 1807 are attached hereto as Exhibit E.

14. Still continuing with the development and testing of VGS devices, another lot of 30W VGS devices (Lot 1808) was fabricated shortly after completion of Lot 1807. Fabrication of the devices of Lot 1808 was completed by at least March 13, 2001. DC test data was taken on the devices of Lot 1808. Some of the results of DC testing of the devices of Lot 1808 are attached hereto as Exhibit F.

15. Still continuing with the development and testing of VGS devices, another lot of 30W VGS devices (Lot 1809) was fabricated shortly after completion of Lot 1808. Fabrication of the devices of Lot 1809 was completed by at least March 30, 2001. DC test data was taken on the devices of Lot 1809. Some of the results of DC testing of the devices of Lot 1809 are attached hereto as Exhibit G.

16. After completion of Lot 1809, work on high power RF devices was suspended while a fundamental technical problem that was being experienced with wide bandgap RF transistors, and that was unrelated to gate pitch or device power, was addressed at Cree. The fundamental technical problem was resolved using research on low power RF devices. During the approximately twelve month period following completion of Lot 1809, no high power devices, whether VGS or uniform pitch, were fabricated at Cree. However, once the fundamental technical problem was resolved, work on VGS devices resumed.

17. Following resolution of the fundamental technical problem referenced above, a lot of 60W devices having variable gate spacing (Lot 3001) was fabricated using a new mask with new gate spacing based on updated thermal simulations. The 60W devices of Lot 3001 were the first high power devices fabricated at Cree since the resolution of the fundamental technical problem referenced above. CAD layouts of the masks for Lot 3001 were completed by at least March 22, 2002. DC testing of the 60W devices of Lot 3001 was completed by at least May 2, 2002. Some of the results of DC testing of the devices of Lot 3001 are attached hereto as Exhibit H.

18. Continuing with the development and testing of VGS devices, another lot of 60W VGS devices (Lot 6001) was fabricated shortly after completion of Lot 3001. Fabrication of the devices of Lot 6001 was completed by at least September 4, 2002. DC test data was taken on the

devices of Lot 6001. Some of the results of DC testing of the devices of Lot 6001 are attached hereto as Exhibit I.

19. Continuing with the development and testing of VGS devices, another lot of 60W VGS devices (Lot 6002) was fabricated shortly after completion of Lot 6001. Fabrication of the devices of Lot 6002 was completed by at least November 7, 2002. DC test data was taken on the devices of Lot 6002. Some of the results of DC testing of the devices of Lot 6002 are attached hereto as Exhibit J.

20. Infrared scans during RF operation of some of the 60W VGS devices described above were taken on or about March 20, 2003. A copy of infrared scans of the 60W devices is attached hereto as Exhibit K. The infrared scans confirm the improved thermal performance of the VGS devices. In particular, the infrared thermal scans confirm that the VGS devices have lower peak junction temperatures and more uniform junction temperatures during RF operation than uniform pitch devices.

21. On April 7, 2003, I executed an Invention Disclosure disclosing the subject matter of the '398 application. A redacted copy of the Invention Disclosure is attached hereto as Exhibit L.

22. Exhibit M is a redacted copy of a letter dated August 29, 2003, requesting that Myers Bigel Sibley & Sajovec, P.A. prepare an application relating to "Variable Gate Transistor Devices" and forwarding a copy of the Invention Disclosure. Exhibit N is a copy of a letter from Myers Bigel Sibley & Sajovec, P.A. dated September 22, 2003, forwarding an initial draft of a patent application for inventor review. Exhibit O is a copy of an email from Myers Bigel Sibley & Sajovec, P.A. dated October 3, 2003, forwarding a revised draft of a patent application for inventor review. Exhibit P is a copy of a letter from Myers Bigel Sibley & Sajovec, P.A. dated October 23, 2003, forwarding a final draft of a patent application for inventor review along with

a Declaration and Power of Attorney. Exhibit Q is a copy of a letter from Myers Bigel Sibley & Sajovec, P.A. dated December 12, 2003, stating that the application was filed on December 12, 2003.

23. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Ronald C. Meadows

Ronald C. Meadows

12/21/2006

Date

Exhibit A

After

$G_S = 0.622 \angle 38.5$ $G_S = 0.617 \angle 39°$

$G_L = 0.794 \angle 30.5$ $G_L = 0.793 \angle 30.9°$

[redacted] 1801 1mm Test

WAFER #6 CW Test w/ Vd=50 ON WAFER

Before Burn

X	Y	Vp	Vgmin	Id100	Idss	PidB	Gain	Vg(Id=90)
1	4	-12	-16	40uA	300	32.9	14.0	~~-9.0~~ -9.5
3	4	-10	-14	5uA	250	32.4	13.7	-7.0
3	7	-11	-18	25uA	270	~~33.5~~	~~13.6~~	~~-10.0~~ ~~-9.0~~ 4 to Accidental
5	4	-11	-16	5uA	250	33.4	14.0	-9.0

fixed tune set w/ 1-6 !!

B

After 1 hr. soak at chuck temp of 120°C

@ Vg(90) & Vd=50 V try ~~100~~ 90°C

X	Y	Vp	Vgmin	Id100	Idss	PidB	Gain	Vg(Id=90mA)
1	4	12 ~~BLEW UP!~~	~~-20~~	~~2mA~~	320	34.2	13.2	-10.0
3	4	10	-16	30uA	240	32.6	13.7	~~-7.0~~
3	7	11	-20	70V$_{BR}$	260	33.7	13.3	-10.5
5	4	BLEW up! @120						

no burn in only heat 120 1.5hr @90 1hr

* BAKED PART

recovered to 100V

125uA

-22

3-4 overnight at 125°C 24hrs Vd=50 Id=100mA 175°C 12Hrs

$V_p = 10$ $V_{gmin} = -16$ $Id100 = 30uA$ $Idss = 250$

$P_{1dB} = 32.9$ Gain = 13.4 $V_g(Id=90) = -7.5$

	PidB	Gain	Vg(Id)
3-7	34.3	13.3	-10.5
L-F	33.9	13.5	-10.0

[redacted]

[redacted]

3:00 P.M.

[redacted]

- die attach works.

my plate

- 30W work
  - eval bd
  - data sheets (w/ Todd)
  - app notes
  - 2.5 - 2.7 GHz balanced amp board [layout/mechanical/electrical test]
- - 10W 3.5 - 3.7 GHz circuit development
  - die attach
  - circuit problem fixes
  - test issues
- - 60W die layout — 28V testing 2 GHz testing.
  - test
  - appnotes
  - data sheets } [redacted]

[redacted]

- - customer support [redacted]

~~test issues w/ 30W die~~

- - advancing FET layout/optimization for second generation FETs
  - unit gate width
  - gate pitch
  - herringbone FET structures.

B

[redacted] 80W push pull program up to 3.0 GHz

layout

[redacted]

Layout tweaks:

posts are all 30x30 inside active area on drain side
30x20 outside (except where redundant one attach 30x30
- metal 2 must overhang by 4

metal 2 is 39.05 wide by gate & drain feeds (38 ok)
3% on redundant bridges

use Suss 10x on corners of reticle for alignment
10um holdback on metal 1 stripe.

4 layouts in 18 & 24mm Ron to fix
1 reticle fix (corners)
L_80_36
L_80_48
L_VGS_36
L_VGS_48

~~pad size changed: source (gate side) 184~~
~~gate 239~~

need to do labels on 18mm set of masks

B

18 mm mesh tweed

-8.05 77.1 [redacted] 68

.5 -5.3 150

18 mm cells

dme L_80.36

L_VGS.36

68
75
143

B

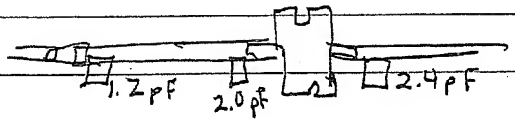
[redacted] 1801-5 evaluation [redacted]

80 um pitch

1 FET still alive

3 blew

Tune is



Baseplate Temp of 21°C

Class B w/ I_{dq} = 250 mA

V_{GS} 3 good to start

D6	I_{dss} = 4.4 A	$P_{1dB} \approx$ 25 W	
D3	= 3.6 A	27.5 W	all 3 are still alive.
C2	4.0	29.0 W	≈ 12dB gain

Wafer #7 11 V_{GS} part w/ 4 parts having bad SAM results

		Before I_{dss}	P_{1dB}	Gain	I_{dss} After	
in 2.14 fixture	C4	4.16A	35 W	11.7	3.8	
•	C6	4.16A	36 W	11.2	3.9	
	C1	3.8 A	39.4 W	11.6	3.5	
	C2	3.7A	30 W	11.5	3.4	
	C3	3.6A	36.4 SMOKED UNDER 11.2 RF drive			
	D15	4.2A	BLEW w/ RF Applied.			
	D17	NO POWER UP!				
Bad SAM	C7	3.9	33W	10.9	3.4	
•	D16	3.9	BLEW DC			
•	C9	4.2	35 W	11.3	3.8	
•	D14	3.8	12	8	3.4	No MOD Fet
Good	A5	4.1	35	10.9	3.7	
	A6	4.0	36	11.0	3.9	
•	B4	3.0	BLEW DC			
•	A7	3.6	↓			
•	A8	3.9	32	10.5	3.5	

Exhibit B

[redacted]

Part_info	Frequency	Vgg	Vdd	Idq	S11	Pin	Pout	Pout (W)
P1801-5_D	1.95	9.5	48.5	1.396	6.420856	24.53744	36.5913	4.561738
P1801-5_D	1.95	9.5	48.5	1.396	6.42873	25.51153	37.55244	5.691724
P1801-5_D	1.95	9.5	48.5	1.396	6.433081	26.50714	38.58405	7.217794
P1801-5_D	1.95	9.5	48.5	1.396	6.435199	27.50511	39.55576	9.027674
P1801-5_D	1.95	9.5	48.5	1.396	6.412097	28.49073	40.48314	11.17672
P1801-5_D	1.95	9.5	48.5	1.396	6.408136	29.52291	41.46164	14.00116
P1801-5_D	1.95	9.5	48.5	1.396	6.375625	30.5125	42.36225	17.22762
P1801-5_D	1.95	9.5	48.5	1.396	6.347703	31.50461	43.14595	20.63454
P1801-5_D	1.95	9.5	48.5	1.396	6.281716	32.5145	43.79975	23.98695
P1801-5_D	1.95	9.5	48.5	1.396	6.225407	33.49173	44.2916	26.86334
P1801-5_D	1.95	9.5	48.5	1.396	6.184964	34.47237	44.68864	29.43502
P1801-5_D	1.95	9.5	48.5	1.396	6.171206	35.42166	44.99288	31.57097
P1801-5_D	1.95	9.3	48.5	1.408	6.46669	24.57142	36.57286	4.542405
P1801-5_D	1.95	9.3	48.5	1.408	6.457596	25.51052	37.52154	5.651372
P1801-5_D	1.95	9.3	48.5	1.408	6.493162	26.52164	38.53461	7.136096
P1801-5_D	1.95	9.3	48.5	1.408	6.474947	27.50884	39.52272	8.959258
P1801-5_D	1.95	9.3	48.5	1.408	6.452583	28.49704	40.45978	11.11676
P1801-5_D	1.95	9.3	48.5	1.408	6.458745	29.52626	41.43617	13.91927
P1801-5_D	1.95	9.3	48.5	1.408	6.44746	30.53307	42.33663	17.12627
P1801-5_D	1.95	9.3	48.5	1.408	6.428197	31.52482	43.13449	20.58017
P1801-5_D	1.95	9.3	48.5	1.408	6.360113	32.52777	43.77258	23.83738
P1801-5_D	1.95	9.3	48.5	1.408	6.302419	33.50505	44.26502	26.69944
P1801-5_D	1.95	9.3	48.5	1.408	6.261435	34.48529	44.65034	29.17656
P1801-5_D	1.95	9.3	48.5	1.408	6.234195	35.42565	44.93807	31.17502
P1801-5_D	1.95	9.1	48.5	1.448	6.530252	24.57374	36.53809	4.506182
P1801-5_D	1.95	9.1	48.5	1.448	6.52763	25.51843	37.4802	5.597828
P1801-5_D	1.95	9.1	48.5	1.448	6.539302	26.52157	38.49183	7.066145
P1801-5_D	1.95	9.1	48.5	1.448	6.551989	27.53009	39.48401	8.879747
P1801-5_D	1.95	9.1	48.5	1.448	6.538649	28.50788	40.41386	10.99982
P1801-5_D	1.95	9.1	48.5	1.448	6.524291	29.51944	41.39551	13.78957
P1801-5_D	1.95	9.1	48.5	1.448	6.513283	30.53516	42.30291	16.99381
P1801-5_D	1.95	9.1	48.5	1.448	6.48534	31.51704	43.10474	20.43968
P1801-5_D	1.95	9.1	48.5	1.448	6.438793	32.53216	43.76778	23.81104
P1801-5_D	1.95	9.1	48.5	1.448	6.388993	33.50945	44.25027	26.60893
P1801-5_D	1.95	9.1	48.5	1.448	6.350168	34.49331	44.63609	29.08099
P1801-5_D	1.95	9.1	48.5	1.448	6.282049	35.43098	44.91757	31.02822

Gain	Npae	Id	Ig
12.05387	6.358692	1.387	-1.85E-05
12.04091	7.960922	1.382	-2.01E-05
12.07691	10.09366	1.383	-2.22E-05
12.05065	12.5923	1.386	-2.51E-05
11.99241	15.53109	1.39	-2.90E-05
11.93873	19.23204	1.405	-3.44E-05
11.84975	23.26612	1.427	-4.17E-05
11.64134	27.12519	1.461	-5.11E-05
11.28525	30.27699	1.512	-6.37E-05
10.79987	32.36533	1.569	-7.94E-05
10.21628	33.64983	1.632	-9.99E-05
9.571218	34.2459	1.691	6.77E-05
12.00144	6.250028	1.404	-1.76E-05
12.01102	7.782584	1.403	-1.90E-05
12.01297	9.799576	1.407	-2.12E-05
12.01388	12.25982	1.412	-2.40E-05
11.96275	15.10377	1.421	-2.77E-05
11.9099	18.6983	1.436	-3.30E-05
11.80355	22.62056	1.458	-3.98E-05
11.60967	26.53069	1.489	-4.91E-05
11.24482	29.61509	1.535	-6.12E-05
10.75997	31.73637	1.589	-7.62E-05
10.16505	32.98932	1.648	-9.62E-05
9.51242	33.71934	1.693	0.000379
11.96434	6.020786	1.445	-1.76E-05
11.96177	7.473879	1.446	-1.91E-05
11.97026	9.416004	1.449	-2.12E-05
11.95392	11.78091	1.455	-2.40E-05
11.90598	14.49298	1.464	-2.77E-05
11.87607	17.98798	1.478	-3.27E-05
11.76775	21.83347	1.498	-3.96E-05
11.5877	25.71788	1.525	-4.86E-05
11.23563	28.99177	1.566	-6.06E-05
10.74082	31.08775	1.616	-7.57E-05
10.14278	32.39153	1.672	-9.53E-05
9.486587	33.39724	1.7	0.000773

Exhibit C

[redacted]

1,7,	-11.2,	120,	-23.0,	2.21,	0.67,	-0.61
2,5,	-10.8,	120,	-25.0,	0.92,	0.34,	-0.33
2,6,	-9.4,	120,	-21.5,	1.13,	0.38,	-0.41
2,7,	-10.8,	120,	-24.5,	2.80,	0.75,	-0.68
3,5,	-13.6,	120,	-31.5,	4.41,	4.23,	-0.66
3,6,	-11.8,	120,	-31.0,	3.46,	4.50,	-0.35
3,7,	-11.6,	120,	-27.0,	3.37,	4.50,	-0.54
3,9,	-14.0,	120,	-28.0,	4.50,	4.50,	-0.30
4,5,	-12.6,	120,	-30.5,	4.50,	4.50,	-0.17
4,8,	-13.6,	120,	-27.0,	4.50,	4.50,	-0.32
4,9,	-14.4,	120,	-31.5,	4.50,	4.50,	-0.32
5,5,	-13.4,	120,	-30.5,	4.50,	4.50,	-0.14
5,8,	-15.0,	120,	-29.5,	4.50,	4.50,	-0.26
6,4,	-13.0,	120,	-25.5,	4.50,	4.50,	-0.54
6,5,	-13.4,	120,	-30.5,	4.50,	4.50,	-0.24
6,7,	-14.2,	120,	-25.5,	4.50,	4.50,	-1.43
7,4,	-11.2,	120,	-21.0,	1.91,	0.76,	-0.83
7,5,	-11.8,	120,	-24.5,	3.01,	0.80,	-0.86
7,6,	-12.6,	120,	-23.5,	4.50,	4.50,	-1.03
7,7,	-14.0,	120,	-25.5,	4.50,	4.50,	-0.59
8,3,	-12.0,	120,	-32.5,	3.88,	2.10,	-0.80

Exhibit D

[redacted]

X	Y	Vp10	Vbr	Vgmin	Idmin	Id100	Ig100
7	2	-8.8	100	-23.5	0.73	1.95	-2.57
11	2	-8.4	100	-20.5	0.28	0.28	-0.09
13	1	-7.6	100	-20.5	0.05	0.05	-0.04
13	2	-8.2	100	-20	0.1	0.1	-0.08
14	1	-7	100	-18.5	0.06	0.05	-0.03
15	1	-6.6	100	-16.5	0.04	0.04	-0.03
15	2	-8.4	100	-19.5	0.07	0.06	-0.06
15	3	-11.2	100	-23.5	0.7	3.79	-0.37
16	2	-8.2	100	-20.5	0.12	0.11	-0.09
17	3	-11	100	-30.5	1.28	3.63	-0.27
18	2	-8.4	100	-19.5	0.16	0.15	-0.13
19	2	-8.4	100	-28.5	0.69	0.64	-0.12
19	3	-10.8	100	-22	0.72	1.67	-0.44
20	2	-8	100	-18.5	0.08	0.08	-0.08
21	2	-8	100	-20.5	0.1	0.1	-0.08
22	1	-6.8	100	-20.5	0.04	0.03	-0.03
22	2	-7.8	100	-21.5	0.12	0.11	-0.09
22	3	-10.4	100	-21.5	0.45	0.79	-0.27
23	1	-7.2	100	-15.5	0.04	0.04	-0.03
23	2	-7.6	100	-17	0.06	0.07	-0.06
23	3	-10.2	100	-21	0.61	0.64	-0.28
24	2	-7.4	100	-18.5	0.1	0.1	-0.06
24	3	-10	100	-22.5	0.36	0.41	-0.25
25	2	-7.2	100	-25	3.04	3.02	-2.53
26	2	-7	100	-17.5	0.06	0.07	-0.06
26	3	-9.6	100	-20.5	0.38	0.39	-0.25
27	3	-9.2	100	-20.5	0.49	0.47	-0.39
28	2	-6.8	100	-17	0.08	0.09	-0.51
29	2	-7.4	100	-34	0.31	0.21	-0.09
29	3	-9	100	-22	0.21	0.24	-0.15
30	2	-8.8	100	-19	0.24	0.25	-0.23
31	3	-8.6	100	-22	0.59	0.65	-0.22

Exhibit E

[redacted]

X	Y	Vp10	Vbr	Vgmin	Id100	Ig100
7	3	-6.2	100	-25	0.45	-0.45
7	5	-6.4	100	-25	0.54	-0.54
8	3	-6.4	100	-25	0.59	-0.59
8	5	-6.8	100	-25	0.69	-0.69
9	3	-6.6	100	-25	0.57	-0.58
9	5	-7.2	100	-25	0.77	-0.76
9	6	-6.8	100	-25	0.72	-0.66
9	9	-6.6	100	-25	2.18	-0.6
10	2	-7.4	100	-25	0.62	-0.62
10	3	-7.4	100	-25	0.62	-0.63
10	4	-7.4	100	-25	0.67	-0.67
10	5	-7.6	100	-25	0.73	-0.72
10	6	-7.4	100	-25	0.66	-0.65
10	8	-6.6	100	-25	0.57	-0.55
11	4	-8	100	-25	1.01	-0.98
11	6	-7.8	100	-25	1.03	-0.87
11	7	-7.6	100	-25	0.95	-0.8
12	2	-8	100	-25	1.64	-1.64
12	4	-8.2	100	-25	1.19	-1.17
12	6	-8	100	-25	1.09	-1.08
12	7	-8	100	-25	1.27	-1.08
12	9	-7	100	-25	2.42	-2.43
13	2	-8.6	100	-25	1.33	-1.33
13	3	-8.6	100	-25	1.08	-1.07
13	4	-8.6	100	-25	1.21	-1.06
13	5	-8.8	100	-25	2.02	-1.43
13	6	-8.6	100	-25	1.23	-0.97
13	7	-8.2	100	-25	0.89	-0.83
13	8	-7.6	100	-25	0.87	-0.64
14	3	-9	100	-25	1.3	-1.3
14	4	-9.2	100	-25	1.21	-1.21
14	6	-9	100	-25	1.04	-1.02
14	7	-8.6	100	-25	0.98	-0.96
14	9	-7.8	100	-25	0.87	-0.84
15	3	-9.4	100	-25	2.18	-2.26
15	4	-9.4	100	-25	1.81	-1.85
15	6	-9.4	100	-25	1.7	-1.52
15	7	-9.2	100	-25	1.78	-1.53
16	6	-9.6	100	-25	2.32	-2.21
16	7	-9.4	100	-25	1.8	-1.68
16	8	-9	100	-25	2	-1.65
16	9	-8.8	100	-25	2.45	-1.63
17	3	-10.2	100	-25	2.49	-2.61
17	5	-10.2	100	-25	1.66	-1.56
17	7	-9.6	100	-25	1.35	-1.3
17	8	-9.4	100	-25	2.09	-2.12
17	9	-9	100	-25	1.1	-1.07
18	5	-10.4	100	-25	2.2	-2.14
18	8	-10	100	-25	1.79	-1.73
18	9	-9.6	100	-25	1.47	-1.46
19	7	-10.4	100	-25	1.96	-1.94

19	8	-10.4	100	-25	2.06	-2.02
21	7	-10.8	100	-25	1.73	-1.72
21	8	-10.8	100	-25	2.11	-2.09
22	7	-11	100	-25	2.54	-2.58
22	8	-11	100	-25	2.5	-2.48
23	6	-10.8	100	-25	2.78	-2.58

Exhibit F

2,2,	-6.4,	-6.8,	100,	-25.0,	0.06,	-0.06
2,5,	-6.8,	-7.2,	100,	-25.0,	0.11,	-0.08
2,6,	-7.2,	-7.6,	100,	-25.0,	0.14,	-0.13
2,8,	-7.0,	-7.4,	100,	-25.0,	0.43,	-0.15
3,3,	-7.0,	-7.6,	100,	-25.0,	12.00,	-49.94
3,6,	-9.4,	-10.2,	100,	-25.0,	0.34,	-0.34
3,8,	-8.8,	-9.4,	100,	-25.0,	0.27,	-0.28
4,5,	-11.2,	-12.0,	100,	-25.0,	1.11,	-0.80
4,7,	-11.6,	-12.2,	100,	-25.0,	7.52,	-0.86
4,8,	-11.4,	-12.0,	100,	-25.0,	2.28,	-0.98
5,3,	-11.2,	-12.0,	100,	-25.0,	1.12,	-1.07
6,2,	-11.6,	-12.2,	100,	-25.0,	1.47,	-1.49
7,2,	-12.8,	-13.6,	100,	-25.0,	10.17,	-10.36
7,3,	-12.8,	-13.6,	100,	-25.0,	3.61,	-3.02
7,6,	-14.0,	-15.0,	100,	-25.0,	12.01,	-2.11

Exhibit G

4,8,	-6.2,	-6.6,	100,	-25.0,	2.52,	-2.50
8,6,	-6.2,	-6.6,	100,	-25.0,	0.28,	-0.28
9,7,	-6.2,	-6.6,	100,	-25.0,	0.19,	-0.19
10,4,	-7.0,	-7.8,	100,	-25.0,	0.27,	-0.28
10,7,	-6.6,	-7.2,	100,	-25.0,	0.61,	-0.30
10,8,	-6.2,	-6.6,	100,	-25.0,	0.22,	-0.20
11,3,	-6.2,	-7.0,	100,	-25.0,	0.47,	-0.46
11,4,	-7.6,	-8.2,	100,	-25.0,	0.34,	-0.33
11,5,	-8.0,	-8.6,	100,	-25.0,	0.84,	-0.83
11,6,	-7.8,	-8.4,	100,	-25.0,	0.51,	-0.51
11,7,	-7.2,	-7.8,	100,	-25.0,	0.47,	-0.38
11,8,	-6.4,	-7.0,	100,	-25.0,	0.27,	-0.26
12,3,	-7.4,	-8.0,	100,	-25.0,	0.45,	-0.46
12,4,	-8.0,	-8.6,	100,	-25.0,	0.67,	-0.67
12,7,	-7.8,	-8.2,	100,	-25.0,	0.47,	-0.47
12,8,	-6.8,	-7.4,	100,	-25.0,	0.33,	-0.33
13,6,	-9.0,	-9.6,	100,	-25.0,	0.61,	-0.60
13,7,	-8.4,	-9.0,	100,	-25.0,	0.51,	-0.52
13,8,	-7.6,	-8.0,	100,	-25.0,	0.32,	-0.31
14,3,	-8.0,	-8.8,	100,	-25.0,	1.40,	-0.57
14,4,	-8.8,	-9.4,	100,	-25.0,	1.02,	-1.02
14,6,	-9.4,	-9.8,	100,	-25.0,	1.10,	-1.11
14,7,	-9.0,	-9.6,	100,	-25.0,	1.87,	-1.91
14,8,	-8.2,	-8.6,	100,	-25.0,	1.05,	-0.51
15,2,	-7.6,	-8.2,	100,	-25.0,	1.36,	-0.66
15,4,	-9.0,	-9.6,	100,	-25.0,	0.86,	-0.87
15,5,	-9.6,	-10.2,	100,	-25.0,	1.15,	-1.07
15,6,	-9.8,	-10.4,	100,	-25.0,	2.00,	-1.96
15,7,	-9.4,	-10.0,	100,	-25.0,	1.19,	-1.18
15,8,	-8.4,	-9.0,	100,	-25.0,	0.62,	-0.61
15,9,	-7.6,	-8.2,	100,	-25.0,	0.37,	-0.26
16,3,	-9.0,	-9.4,	100,	-25.0,	6.33,	-6.35
16,4,	-9.4,	-10.0,	100,	-25.0,	1.02,	-0.91
16,5,	-9.8,	-10.4,	100,	-25.0,	1.39,	-1.36
16,6,	-10.2,	-10.8,	100,	-25.0,	1.47,	-1.47
16,9,	-8.2,	-8.8,	100,	-25.0,	0.63,	-0.61
17,4,	-9.8,	-10.4,	100,	-25.0,	0.78,	-0.75
17,6,	-10.6,	-11.2,	100,	-25.0,	1.14,	-1.13
17,8,	-10.0,	-10.8,	100,	-25.0,	0.88,	-0.72
18,2,	-9.0,	-9.6,	100,	-25.0,	3.52,	-13.43
18,3,	-9.6,	-10.0,	100,	-25.0,	0.83,	-0.82
18,4,	-10.2,	-10.6,	100,	-25.0,	1.42,	-1.13
18,5,	-10.4,	-11.0,	100,	-25.0,	1.72,	-1.33
18,6,	-10.8,	-11.4,	100,	-25.0,	1.68,	-1.69
18,7,	-10.8,	-11.4,	100,	-25.0,	1.48,	-1.47
19,4,	-10.4,	-10.8,	100,	-25.0,	1.19,	-1.18
19,5,	-10.6,	-11.2,	100,	-25.0,	1.42,	-1.44
19,7,	-10.8,	-11.6,	100,	-25.0,	1.52,	-1.50
20,3,	-10.2,	-10.6,	100,	-25.0,	1.03,	-1.03
20,4,	-10.4,	-11.0,	100,	-25.0,	1.44,	-1.42
20,5,	-10.8,	-11.4,	100,	-25.0,	1.86,	-1.67
20,6,	-11.2,	-11.8,	100,	-25.0,	2.28,	-2.28

[redacted]

20,7,	-11.2,	-11.8,	100,	-25.0,	1.59,	-1.61
21,1,	-10.6,	-11.0,	100,	-25.0,	2.15,	-2.12
21,5,	-11.2,	-11.8,	100,	-25.0,	1.31,	-1.22
21,6,	-11.6,	-12.2,	100,	-25.0,	1.48,	-1.48
21,7,	-11.6,	-12.4,	100,	-25.0,	1.46,	-1.47
22,1,	-11.2,	-11.6,	100,	-25.0,	4.19,	-3.57
22,2,	-10.6,	-11.0,	100,	-25.0,	1.74,	-1.52
22,3,	-10.8,	-11.2,	100,	-25.0,	1.23,	-1.21
22,5,	-11.2,	-11.8,	100,	-25.0,	5.02,	-2.48
22,6,	-11.6,	-12.2,	100,	-25.0,	3.84,	-2.24
22,7,	-11.8,	-12.4,	100,	-25.0,	2.34,	-1.85
23,2,	-10.8,	-11.2,	100,	-25.0,	2.46,	-3.18
23,3,	-11.0,	-11.4,	100,	-25.0,	1.54,	-1.55
23,4,	-11.0,	-11.6,	100,	-25.0,	1.28,	-1.27
23,5,	-11.4,	-12.0,	100,	-25.0,	1.68,	-1.49
23,7,	-11.8,	-12.4,	100,	-25.0,	1.70,	-1.68
23,8,	-11.4,	-12.0,	100,	-25.0,	1.11,	-1.12
23,9,	-11.0,	-11.6,	100,	-25.0,	1.16,	-1.13
24,2,	-11.0,	-11.6,	100,	-25.0,	3.89,	-2.52
24,3,	-11.0,	-11.6,	100,	-25.0,	1.18,	-1.17
24,4,	-11.2,	-11.8,	100,	-25.0,	1.30,	-1.26
24,6,	-11.6,	-12.2,	100,	-25.0,	1.40,	-1.40
24,7,	-11.8,	-12.4,	100,	-25.0,	1.74,	-1.71
24,8,	-11.2,	-11.8,	100,	-25.0,	0.95,	-0.93
25,3,	-11.4,	-11.8,	100,	-25.0,	0.81,	-0.81
25,4,	-11.6,	-12.0,	100,	-25.0,	2.47,	-2.32
25,5,	-11.6,	-12.0,	100,	-25.0,	0.93,	-0.94
25,6,	-11.8,	-12.4,	100,	-25.0,	1.20,	-1.21
25,7,	-12.0,	-12.8,	100,	-25.0,	1.46,	-1.46
25,8,	-11.6,	-12.2,	100,	-25.0,	1.01,	-0.99
26,1,	-14.6,	-15.0,	100,	-25.0,	11.31,	-9.82
26,2,	-15.2,	-18.4,	100,	-25.0,	6.34,	-4.66
26,3,	-11.4,	-11.8,	100,	-25.0,	1.05,	-1.06
26,5,	-11.4,	-12.0,	100,	-25.0,	1.21,	-1.23
26,6,	-11.8,	-12.4,	100,	-25.0,	1.31,	-1.31
26,7,	-12.0,	-12.6,	100,	-25.0,	1.34,	-1.31
26,8,	-11.8,	-12.2,	100,	-25.0,	1.04,	-1.02
26,9,	-12.2,	-12.8,	100,	-25.0,	1.42,	-1.33
27,2,	-11.8,	-12.2,	100,	-25.0,	2.26,	-2.24
27,4,	-11.4,	-11.8,	100,	-25.0,	1.40,	-1.10
27,5,	-11.4,	-12.0,	100,	-25.0,	1.01,	-1.03
27,7,	-11.8,	-12.2,	100,	-25.0,	1.04,	-1.04
27,8,	-11.8,	-12.4,	100,	-25.0,	1.20,	-1.14
28,2,	-12.2,	-12.6,	100,	-25.0,	2.86,	-2.76
28,4,	-11.2,	-11.6,	100,	-25.0,	0.77,	-0.77
28,5,	-11.2,	-11.8,	100,	-25.0,	0.91,	-0.91
28,7,	-11.8,	-12.2,	100,	-25.0,	1.01,	-1.04
29,2,	-12.6,	-13.0,	100,	-25.0,	3.95,	-3.13
29,3,	-11.6,	-12.0,	100,	-25.0,	0.94,	-0.79
29,5,	-11.2,	-11.6,	100,	-25.0,	0.59,	-0.59
29,7,	-11.8,	-12.2,	100,	-25.0,	1.00,	-0.87
30,2,	-13.4,	-13.8,	100,	-25.0,	4.06,	-3.02

31,3,	-11.6,	-12.0,	100,	-25.0,	1.15,	-1.14
31,4,	-11.0,	-11.6,	100,	-25.0,	0.79,	-0.76
31,5,	-11.0,	-11.4,	100,	-25.0,	0.50,	-0.49
31,7,	-11.8,	-12.4,	100,	-25.0,	1.03,	-1.03
32,4,	-11.0,	-11.6,	100,	-25.0,	0.80,	-0.81
32,5,	-11.0,	-11.4,	100,	-25.0,	0.58,	-0.59
32,6,	-11.2,	-11.6,	100,	-25.0,	0.68,	-0.68
32,7,	-11.8,	-12.4,	100,	-25.0,	1.17,	-1.13
33,3,	-12.4,	-12.8,	100,	-25.0,	1.23,	-1.23
33,4,	-11.2,	-11.6,	100,	-25.0,	0.73,	-0.74
33,5,	-11.0,	-11.4,	100,	-25.0,	0.59,	-0.59
33,7,	-12.4,	-12.8,	100,	-25.0,	2.36,	-1.83
34,3,	-14.0,	-14.6,	100,	-25.0,	2.86,	-2.60
34,4,	-11.4,	-11.8,	100,	-25.0,	0.95,	-0.95
34,5,	-11.2,	-11.6,	100,	-25.0,	0.67,	-0.67
35,5,	-11.6,	-12.0,	100,	-25.0,	0.79,	-0.79
35,6,	-12.2,	-12.6,	100,	-25.0,	1.08,	-1.09

Exhibit H

[redacted] [redacted]

X	Y	Vth
2	5	-7.4
3	5	-7.9
4	3	-8.2
4	5	-7.8
4	6	-7.9
5	5	-8.2
6	5	-7.9
7	3	-7.9
7	4	-12.8
7	5	-8.3
7	6	-8.4
8	3	-7.9
8	4	-8.4
8	5	-8.6
8	6	-8.4
9	3	-8.1
9	4	-8.4
9	5	-8.6
9	6	-8.7
10	3	-8.2
10	5	-8.6
10	6	-9.3
11	3	-8.3
11	4	-8.7
11	6	-8.7
12	2	-8.3
12	3	-8.6
12	4	-8.8
12	5	-8.9
12	6	-8.9
13	2	-8.2
13	3	-8.8
13	4	-8.9
13	5	-9.1
13	6	-9.1
14	2	-7.9
14	4	-8.9
14	5	-9.2
14	6	-9.6
14	7	-11.7
15	4	-8.9
15	5	-9.3
15	6	-9.3
15	7	-9.2
16	2	-8.2
16	3	-8.6
16	4	-8.9
16	5	-9.3
16	6	-9.3
17	3	-8.7
17	4	-8.9

[redacted]

X	Y	Vth
17	5	-9.4
17	6	-9.4
18	2	-8.8
18	4	-8.9
18	5	-9.7
18	6	-9.7
19	4	-9.2
19	5	-9.9
19	7	-9.9
20	2	-8.8
20	4	-9.3
20	5	-9.9
20	7	-9.9
21	2	-8.8
21	3	-9.1
21	4	-9.4
21	5	-9.9
21	6	-9.9
21	7	-9.9
22	3	-8.9
22	4	-9.7
22	5	-9.9
22	6	-9.8
23	1	-11.2
23	3	-9.1
23	4	-9.6
23	5	-9.9
23	6	-9.9
23	7	-9.9
24	2	-8.9
24	3	-9.2
24	4	-9.6
24	5	-9.9
24	6	-10.2
24	7	-10.2
25	2	-8.8
25	3	-9.3
25	5	-9.8
25	6	-10.2
26	3	-9.4
26	6	-9.9
26	7	-10.3
27	3	-9.2
27	4	-9.9
27	5	-10.1
27	6	-10.4
27	7	-10.4
28	3	-9.3
28	4	-9.9
28	5	-12.3
28	6	-10.3

X	Y	Vth
28	7	-10.9
29	3	-9.8
29	5	-13.4
29	6	-10.3
29	7	-11.3
30	4	-11.6
30	5	-11.1
30	7	-13.2
31	4	-12.2
31	5	-11.1
32	2	-11.6
32	4	-11.2
32	5	-11.6
34	6	-11.8

Exhibit I

2,3,	-10.1,	100,	-26.0,	0.05,	-0.05
3,5,	-8.8,	100,	-26.0,	0.01,	-0.01
3,6,	-9.4,	100,	-26.0,	12.00,	-3.03
4,2,	-9.4,	100,	-26.0,	0.12,	-0.12
5,2,	-9.3,	100,	-26.0,	0.45,	-0.47
5,3,	-8.1,	100,	-26.0,	0.01,	-0.01
5,6,	-10.1,	100,	-26.0,	12.00,	-7.79
6,1,	-12.1,	100,	-26.0,	0.21,	-0.21
6,2,	-9.2,	100,	-26.0,	0.01,	-0.02
6,3,	-8.6,	100,	-26.0,	0.01,	-0.01
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7,3,	-8.2,	100,	-26.0,	12.00,	0.00
7,5,	-8.2,	100,	-26.0,	0.01,	-0.01
8,1,	-12.1,	100,	-26.0,	0.65,	-0.65
8,2,	-9.3,	100,	-26.0,	0.02,	-0.02
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Exhibit J

[redacted]

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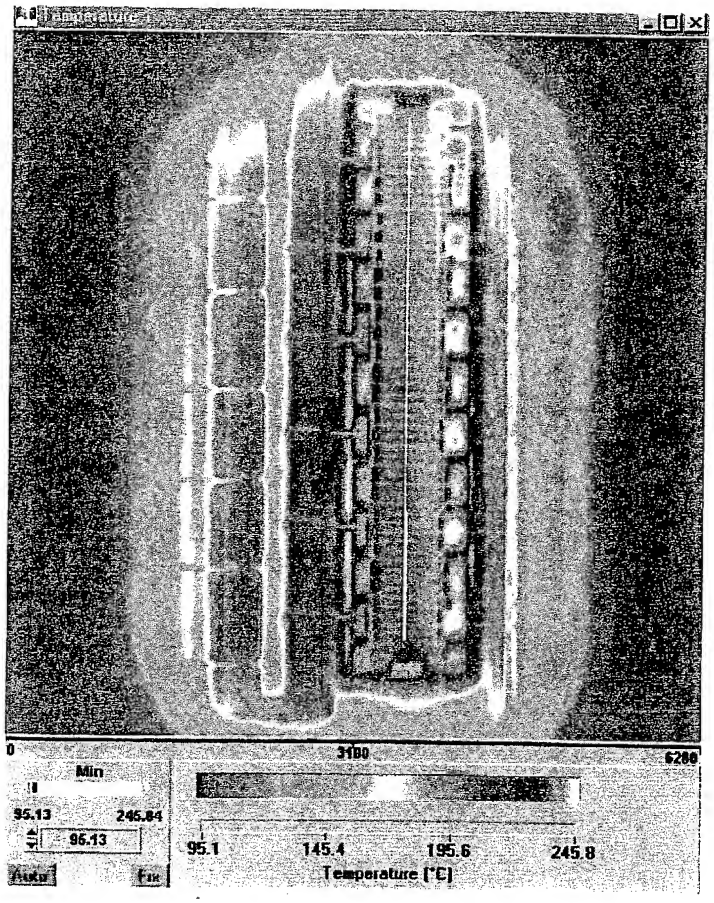
12,7,	-19.7,2.39,	100,	-26.0,	12.00,	-0.71,	-26.0

Exhibit K

Good_A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245.8
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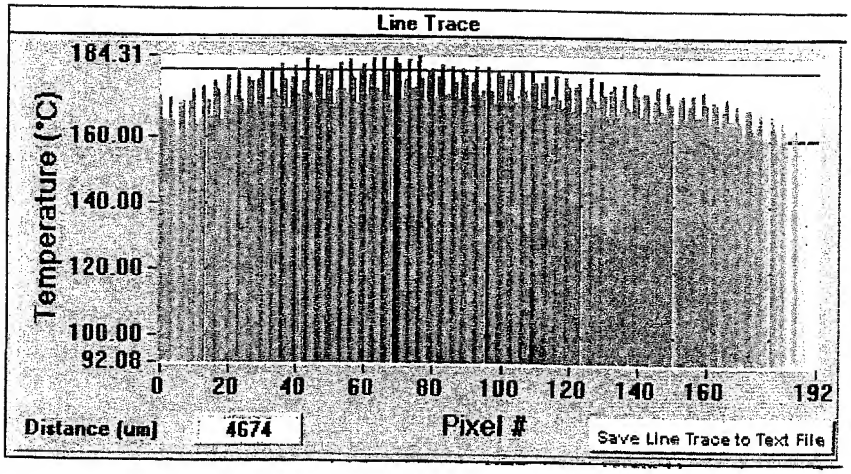
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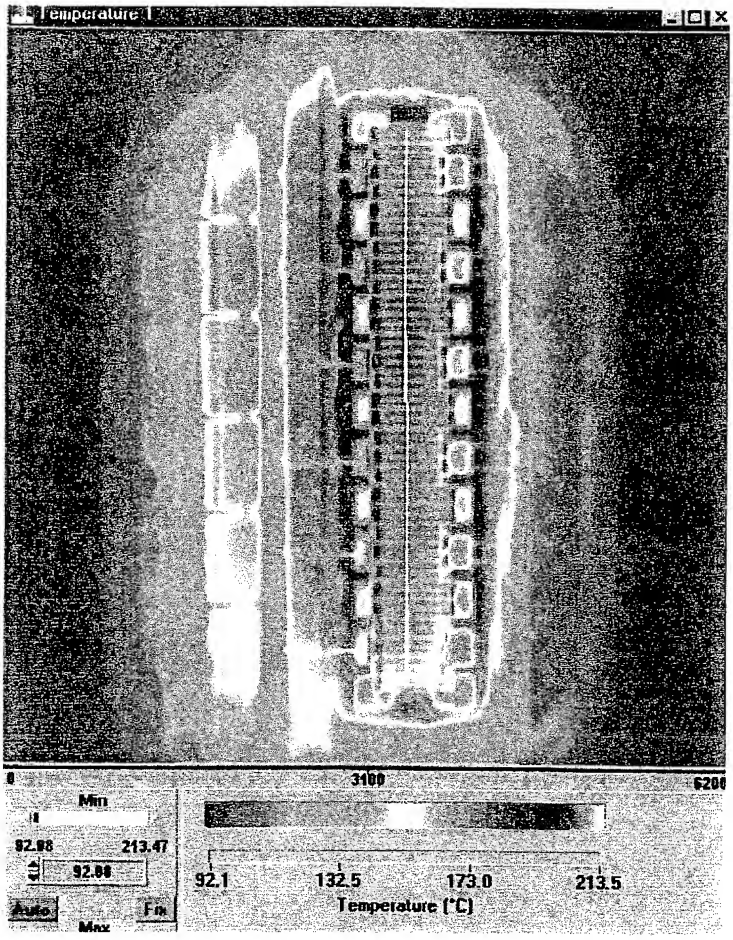
Pixel #
Save Line Trace to Text File

Good_B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Max
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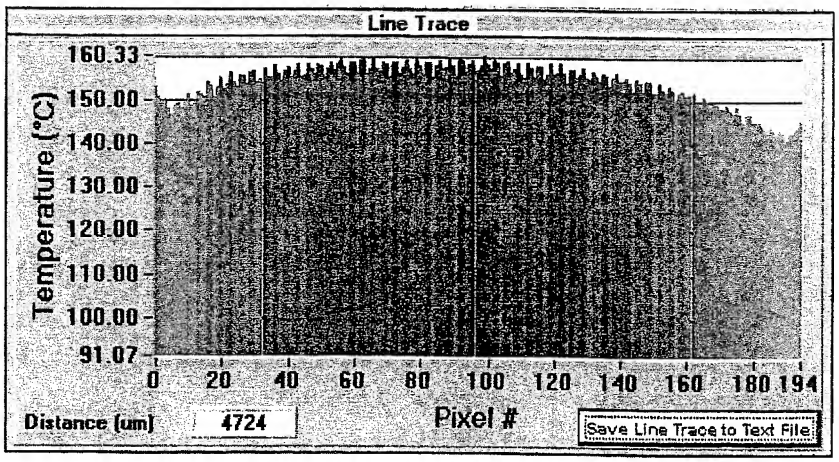
173.0
213.5
Temperature (°C)


Line Trace
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100
120
140
160
180
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Distance (um)
4724
Pixel #
Save Line Trace to Text File

Exhibit L

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Filing Recommendation		For IP Committee Use
IP Committee Review Date:		Disclosure Number: [redacted]
Committee Recommendation: ☐ File: Disclosure Complete ☐ File: Prepare Full Disclosure ☐ Do Not File	☐ Publish Without Filing ☐ Review Further ☐ Keep as Trade Secret	Date Opened: [redacted]
Comments:		

Invention Disclosure

To: Associate General Counsel for Intellectual Property

1. Invention Title: Enhanced RF Power FET performance through Variable Gate Pitch

2. Inventors:

	Inventor No. 1	Inventor No. 2	Inventor No. 3
Full name	Ronald C. Meadows		
Home Address	355 Dreamcatcher Trail Youngsville, NC 27596		
Work Phone	(919) 313-5612		
Citizenship	US		
Department	406		
Manager	John Palmour		
Wrote Disclosure	☒ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No

Attach additional sheets if necessary

3. Date invention conceived: [redacted] Date invention reduced to practice: [redacted]

4. [redacted]

5. [redacted]

6. [redacted]

7. [redacted]

8. [redacted]

Remember to have each page of your invention disclosure signed and dated by a witness.

Please attach this cover form to your invention disclosure, along with any relevant documentation. [redacted]

Inventor's Full Signature	Date	Witnessed, read and understood:	Date
(1) Ronald C. Meadows	[redacted]	(1) [redacted]	[redacted]
(2)		(2)	
(3)		(3)	

PF1 Rev.8/2002

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Description of Invention

Answer each of the following questions about your invention. Use additional space or attach additional sheets as necessary. Attach copies of notes, diagrams, lab notebooks, journal articles, etc. if available. Have a witness sign and date each sheet of the disclosure, including additional sheets.

1. Provide a brief description of the invention. What problem does it solve, and how does it solve the problem?

   The biggest issues a designer has to contend with high power RF transistors are: heat, cost, and RF performance. The devices generate large amounts of heat, necessitating the use of large heatsinks with fans to cool base station amplifiers to ensure good function and reliability. This adds to the size of the amplifier heatsink and increases electrical consumption, which drives up both initial and operating costs. As a device or an amplifier heat up, performance degrades with regard to gain, linearity, and device reliability. The invention addresses these problems by incorporating a variable gate spacing scheme within the device. It lowers peak junction temperature and allows all gate fingers of the device run at approximately the same temperature. The result is a device with better linear gain, better linearity, and better long-term device reliability. The invention could also used to reduce die area for a given peak junction temperature if cost were to take precedence over device performance and reliability.

2. How does the invention differ from present technology? What are the novel or unusual features of the invention? What advantages does it possess?

   Current generation high power RF transistors use an even spacing, or pitch, between gates. The thermal profile of these devices is roughly a bell curve shape with the center gate fingers of the die being the hottest and with the outer most fingers exhibiting a dramatic reduction in operating temperature. The uneven temperature distribution also reduces device linearity. RF phasing errors along both the gate manifold and the individual gate fingers are present due to differing gate resistance as a function temperature. To address these issues designers either widen this uniform space or shorten the gate width's whilst adding gate fingers to achieve an equal net active area. Both solutions successfully spread the head load generated in the center of the device over a wider area, but neither address' the uneven temperature distribution across the device, or its associated linearity reduction. These designs also cause a net increase in die area compared to a given standard gate pitch, thus reducing the total number of die available per wafer yielding an increase in individual die cost. The current invention uses variable spacing between the gate fingers to achieve a nearly flat temperature profile across the device. Peak junction temperature is reduced and RF linearity performance is greatly improved. The resultant device is also smaller than the previous solutions, resulting in a cheaper RF device.

Inventor's Full Signature	Date	Witnessed, read and understood:	Date
(1) Ronald C. Mendes	[redacted]	(1) [redacted]	[redacted]
(2)		(2)	
(3)		(3)	

3. Describe specific embodiments or examples of the invention, if any. Does the invention have any alternative embodiments? Enclose sketches, drawings, photographs and other materials that help illustrate the description.

Two design approaches were followed for determining optimal gate spacing to achieve a flat temperature profile. The first was thermal modeling using Harvard Thermal Incorporated TAS software. Simulations on a 30-watt SiC MESFET with a nominal gate pitch of 80 μM as a reference device predicted the results shown in Figure 1.

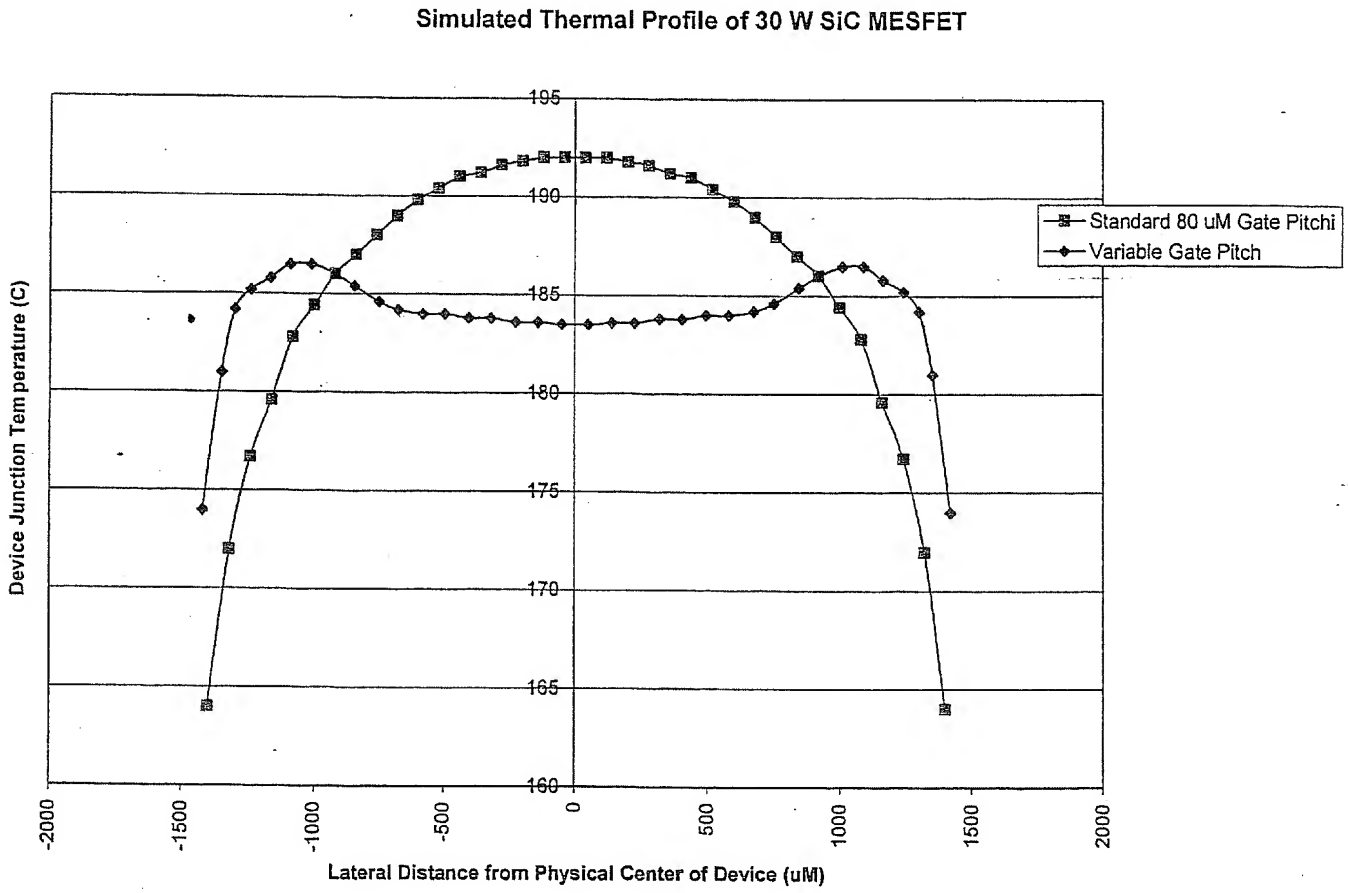


Figure 1.

Figure 2 shows the resultant gate manifold networks for both the 80 uM device and the variable gate pitch one. Only the right half of each device is shown since they are symmetrical about the y-axis of the die.

Inventor's Full Signature	Date	Witnessed, read and understood:	Date
(1) [redacted]	[redacted]	(1) [redacted]	[redacted]
(2)		(2) [redacted]	
(3)		(3)	

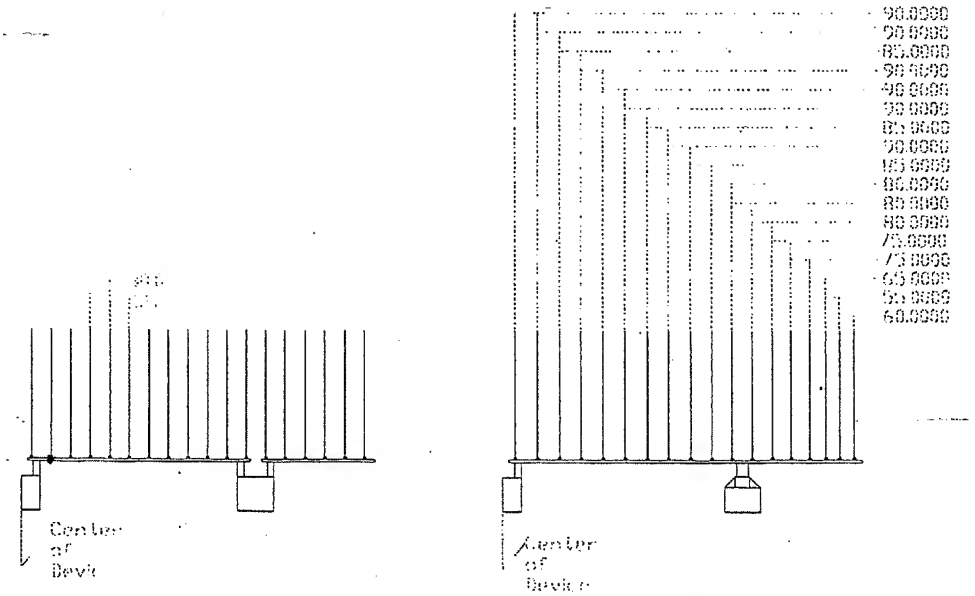


Figure 2.

Both devices were fabricated using [redacted] Devices of both configurations were built up in packages and measure for RF performance. Figure 3 shows the typical RF performance from the devices.

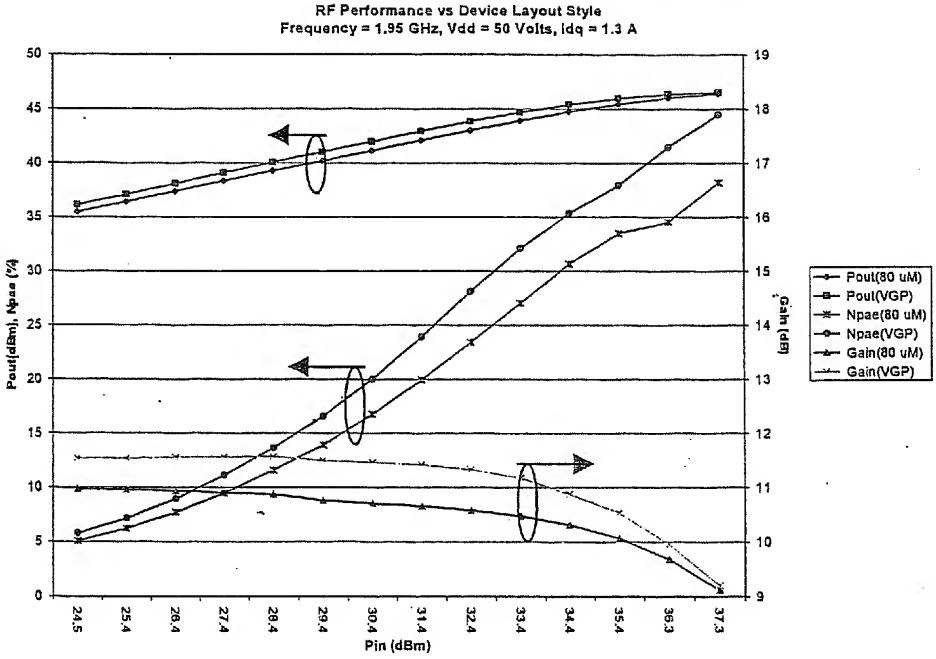


Figure 3.

Inventor's Full Signature	Date	Witnessed, read and understood:	Date
(1) Ronald C. Moulouse	[redacted]	(1) [redacted]	[redacted]
(2)		(2)	
(3)		(3)	

The variable gate pitch FET's performed much better than the reference devices showing increases of 0.5 dB gain and 0.5 dBm in output power.

[redacted] However if you use the typical number of 0.02 dBxC/W derating value for increasing device temperature then the junction temperatures of the variable gate pitch FET's were running about 25 C cooler.

The second method used for variable gate pitch devices was to start with a 92 uM pitch for the center fingers, then do a pseudo linear reduction outward for most of the FET, then tightly space the outermost fingers. This experiment was performed using a 60 watt SiC MESFET device. The gate manifolds are shown in Figure 4. Once again only half of the manifolds are shown due to symmetry.

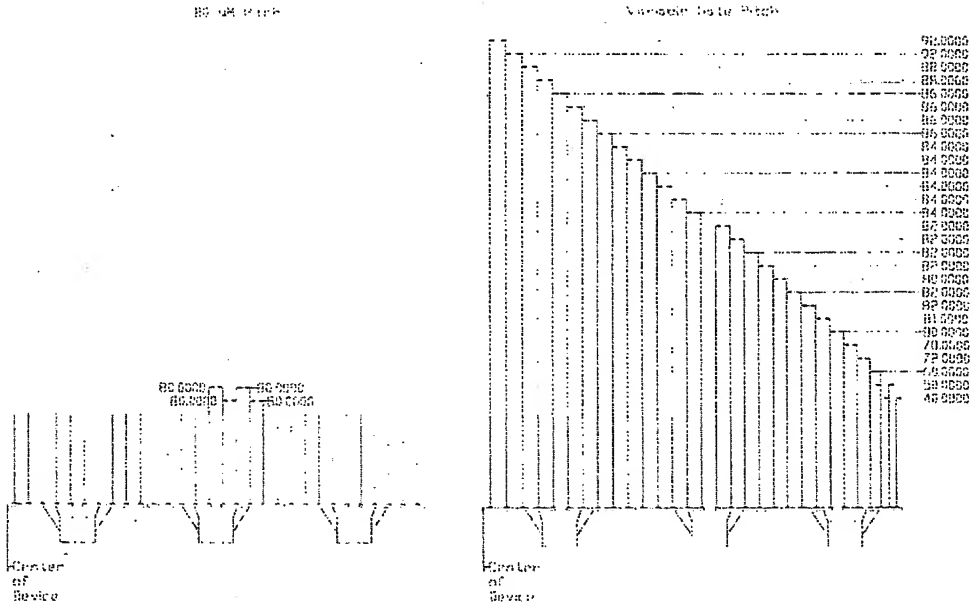
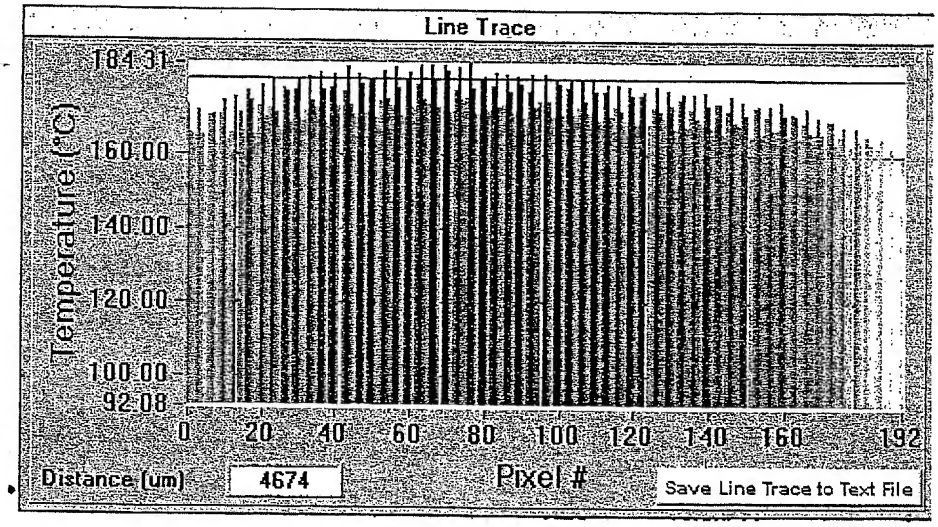


Figure 4.

[redacted] 60 watt devices of both the reference 80 uM and the latest version of variable gate pitch were assembled for thermal imaging. Measurements were taken with a base plate temperature of 90 C with Vdd = 50 volts, and Idq = 1.8 A. Figure 5 shows a side by side comparison of the thermal profile for each device type. Notice that the variable gate pitch FET is running approximately 25 C cooler. This number verifies the results presented for the 30 watt device.

Inventor's Full Signature	Date	Witnessed, read and understood:	Date
(1) Kimel C. Mendoza	[redacted]	(1) [redacted]	[redacted]
(2)		(2)	
(3)		(3)	

80 uM Pitch Device



Variable Gate Pitch Device

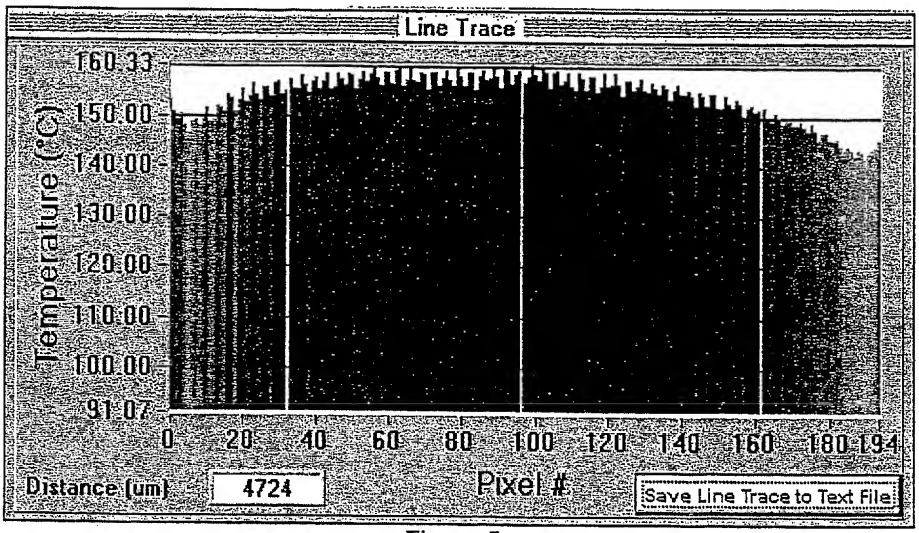
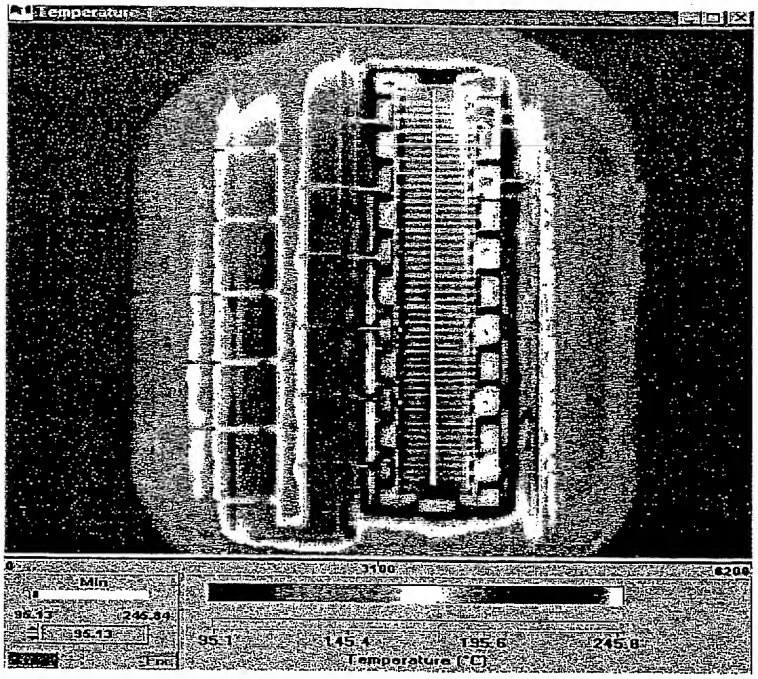


Figure 5.

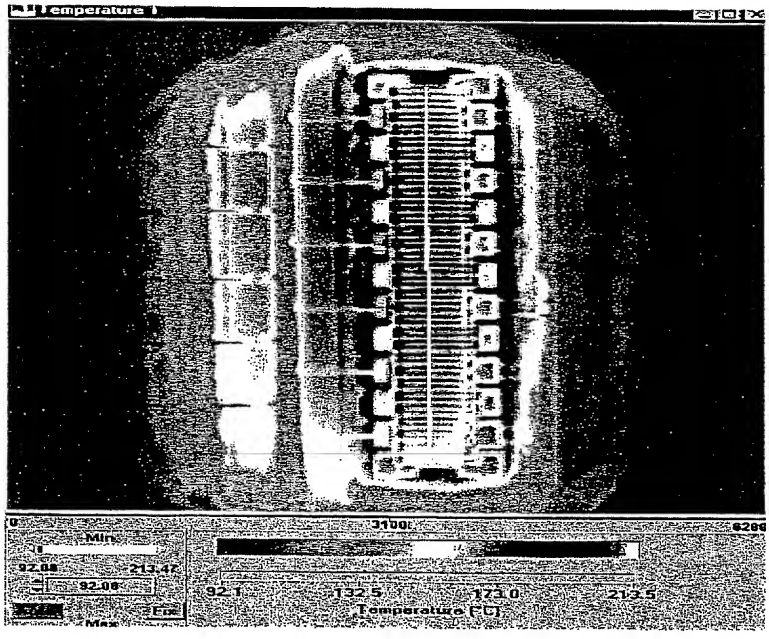
Figure 6 is the overhead view of the previous parts. The temperature profile of the variable gate pitch device isn't perfect so more optimization needs to be done to fully realize the best performance that the device can have.

Inventor's Full Signature	Date	Witnessed, read and understood:	Date
(1) Ronald C Mendows	[redacted]	(1) [redacted]	[redacted]
(2)		(2)	
(3)		(3)	

80 uM Pitch Device



Variable Gate Pitch Device



Inventor's Full Signature	Date	Witnessed, read and understood:	Date
(1) Ronald C. Martinez	[redacted]	(1) [redacted]	[redacted]
(2)		(2)	
(3)		(3)	

RF characterization for the 60 watt FET's showed performance enhancements along the lines of the increase seen on the 30 watt FET's. 25 Degrees of temperature reduction should have a very positive impact on both RF performance and reliability.

4. What are possible applications for the invention? In addition to immediate applications, are there other uses that might be feasible in the future?

   The invention is best applied to high power density technologies such as GaN and SiC, though it could be extended to include most RF power device structures.

5. List any documents or publications that relate to important aspects of this invention.

   None that I am aware of.

Inventor's Full Signature	Date	Witnessed, read and understood:	Date
(1) Kenneth C. Mearburn	4/7/03	(1) [redacted]	
(2)		(2)	
(3)		(3)	

Exhibit M

CREE

4600 Silicon Drive • Durham, NC 27703 • (919) 313-5300 • (919) 313-5452 FAX

09-02-03 AU:41 IN

August 29, 2003

VIA FEDERAL EXPRESS

Timothy J. O'Sullivan, Esq.
Myers Bigel Sibley & Sajovec, P.A.
4140 Parklake Avenue, Suite 600
Raleigh, NC 27612

Re: New U.S. Application entitled
Variable Gate Pitch Transistor Devices
Our Ref.: P0376

Dear Tim:

Please prepare and file a non-provisional patent application for the invention described in the enclosed invention disclosure. If you have any questions about the disclosure, please do not hesitate to contact the inventor, Ron Meadows, directly.

Please send carbon copies of all drafts and correspondence for this case to my attention.

Thank you for your attention to this matter. If you have any questions, please do not hesitate to contact me.

Very truly yours,

Enclosures
MCS-B611

Exhibit N

MYERS BIGEL SIBLEY & SAJOVEC, P.A.

PATENT LAWYERS

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D. Randal Ayers
David D. Beatty
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Needham J. Boddie, II
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Robert N. Crouse
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Devin R. Jensen
Laura M. Kelley
Shawna C. Lemon, Ph.D.
Karen A. Magri, Ph.D.
Robert M. Meeks
Mary L. Miller, Ph.D.*[2]
D. Scott Moore
James D. Myers
Timothy J. O'Sullivan
David K. Purks
Julie H. Richardson
F. Michael Sajovec
Grant J. Scott
Kenneth D. Sibley
Elizabeth A. Stanek
Richard P. Vitek
Karen L. Wade, Ph.D.*[3]

September 22, 2003

Mr. Ronald C. Meadows
Cree, Inc.
4600 Silicon Drive
Durham, North Carolina 27703

Re: *Variable Gate Pitch Transistor Devices*
Cree Docket No.: P0376; Our File: 5308-376

Dear Ron:

Enclosed is an initial draft of a patent application directed to the above-identified invention for your review. This is only a draft, so feel free to make additions, deletions, substitutions, and the like.

As you know, it is essential that the patent application, as filed, be technically accurate and complete, and that it set forth the best mode of carrying out the invention, because new matter may not be added to the descriptive portion after filing. We therefore ask that you carefully review the draft for technical accuracy and completeness, and advise us of any suggested changes or corrections. Your changes and suggestions will be carefully considered in the preparation of the final draft.

Out of an abundance of caution, we are requesting that you confirm that the proper inventive entity has been identified for the claimed invention(s). As you may be aware, inventorship is determined by the subject matter of the claimed invention. Generally stated, to be an inventor one must have made an actual contribution to the conception of the operative invention that is claimed. There may be joint inventorship even though the joint inventors (a) did not work physically together or at the same time, (b) did not make an equal contribution, or (c) did not make a contribution to the subject matter of every claim of the patent. A worker who merely carries out the instructions of another or only provides implementing devices to carry out another's ideas where the effort to do so is the exercise of one of ordinary skill is not typically an inventor. Further, persons listed as contributing to an article describing or related to the invention are not necessarily inventors. Please feel free to call with any questions that you may have on this issue.

Mailing Address:
PO Box 37428
Raleigh, NC 27627

P: (919) 854-1400
F: (919) 854-1401
Int'l: + 1 919 854 1400

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4140 Parklake Ave.
Suite 600
Raleigh, NC 27612

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[2]Licensed in GA
[3]Licensed in CO

We would also like to point out that an inventor is required to make a Declaration when their application is filed in the U.S. Patent and Trademark Office (USPTO), acknowledging a duty to disclose information of which they are aware and which may be considered to be material to the examination of the application. "Material" in this respect is defined as information that a reasonable examiner would likely consider important in deciding whether to issue a patent. "Material" information as defined above may possibly include devices, products, publications, etc. that are similar to the invention and were publicly known before the invention, and it may also include any public disclosure, commercial use, or offer of sale of the invention more than one year prior to the filing date of the application. The USPTO encourages applicants to carefully examine 1) prior art cited in search reports of a foreign patent office in a counterpart application and 2) the closest information over which it is believed any pending claim patentably defines to ensure that any "material" information contained therein is disclosed to the USPTO.

If you are aware of any information that you believe might be considered "material," it is vitally important that it be brought to our attention as soon as possible (delays may result in a loss of patent term). We can then make a determination whether the information should be brought to the attention of the Patent and Trademark Office under the applicable rules. Please also be aware that the duty to disclose "material" information continues throughout pendency of the application, until the application issues as a patent.

You should also be aware that certain activities either in the United States or foreign countries prior to filing of the application in the United States may have a bearing on the ability to file corresponding applications in foreign countries under the applicable international treaty. These activities could include public disclosure of the invention in either written or oral form, such as published articles, patents, product announcements, and proposals, as well as through commercial exploitation of the invention, including public demonstrations, offers to sell, and sale of products incorporating the invention. If you would like to preserve your right to file corresponding foreign applications on this invention, we recommend that all such activities be avoided until the U.S. application is on file.

Pursuant to recent changes in the law, a U.S. application will be published approximately eighteen months after the earliest priority date to which the application is entitled, unless a specific non-publication request is made. Publication may in some circumstances provide additional infringement damages. There are additional fees associated with publication and third parties may submit references against the published application to the Patent Office. A request to not publish the application must be filed at the time of filing the application and must include a certification that the invention has not and will not be the subject of an application filed in a foreign country (e.g., under an international agreement such as the PCT) that requires eighteen-month publication. If you later wish to file an application in a foreign country, we must promptly rescind the non-publication request to avoid abandonment of the application. A request to withhold publication will incur additional fees and expenses. If you would like for us to file a request to prevent publication of the application, please inform us immediately in writing. We will not request non-publication of the application unless you instruct us to do so.

Once you have had an opportunity to review the draft application, please let us know. If possible, we would like your comments as soon as possible. As always, please feel free to call us with any questions that you may have.

Best regards.

Sincerely,

Timothy J. O'Sullivan

TJO/tb
Enclosures

Exhibit O

Brown, Traci

From: O'Sullivan, Timothy
Sent: Friday, October 03, 2003 2:39 PM
To: 'ron_meadows@cree.com'
Cc: [redacted]
Subject: Updated VGP Specification

5308-376 Specification.DOC

Ron:

Attached please find a revised specification for the application. There were no major changes but ifyou have not had a chance to look at the previous draft yet, I thought it would save time if I sent this one. I think I caught all the typos. The drawings have not changed.

Tim

Timothy J. O'Sullivan
Myers Bigel Sibley & Sajovec, P.A.
P.O. Box 37428
Raleigh, NC 27627
(919) 854-1400 Voice
(919) 854-1401 Fax
email address tosullivan@myersbigel.com

Exhibit P

MYERS BIGEL SIBLEY & SAJOVEC, P.A.

PATENT LAWYERS

Jarett K. Abramson	Robert N. Crouse	Robert M. Meeks	F. Michael Sajovec
D. Randal Ayers	Robert W. Glatz	Mary L. Miller, Ph.D.*2	Grant J. Scott
David D. Beatty	Scott C. Ha	[illegible] Moore	Kenneth D. Sibley
Mitchell S. Bigel	Devin R. Je		Elizabeth A. Stanek
Needham J. Boddie, II	Laura M. F		
Lynne A. Borchers*1	Shawna C. [illegible]		
James R. Cannon	Karen A. Magri, Ph.D.		

Ref: 5308-376
Dept:

Date: 23OCT03 SHIPPING $9.27
Wgt: 1 LBS SPECIAL $0.42
HANDLING $0.00
SERVICE: STANDARD OVERNIGHT TOTAL $9.69
TRACK: 6018 7718 0819

October 23, 2003

Via Federal Express

Mr. Ronald C. Meadows
Cree, Inc.
4600 Silicon Drive
Durham, North Carolina 27703

Re: *Non-Uniform Gate Pitch Semiconductor Devices*
Cree Docket No.: P0376; Our File: 5308-376

Dear Ron:

Enclosed is the original proposed patent application directed to the above invention. Also enclosed are the Declaration and Power of Attorney (attached to the application) and the Assignment confirming ownership in Cree, Inc. The application includes your comments to the earlier draft, which were most helpful.

Please carefully review the application to ensure that it is accurate and complete in all respects and advise us if there are any suggested changes or corrections. If the application is fully satisfactory, you should read and then execute the Declaration and Power of Attorney attached to the application. Please note that the application must be complete in all respects, i.e., all changes must be made before the Declaration and Power of Attorney is executed. In the event any changes are made, each such change to the patent application must be initialed and dated. The Assignment should be executed in the presence of a Notary Public who will properly notarize the document.

Please return all original, executed documents for filing with the United States Patent Office.

Sincerely,

Timothy J. O'Sullivan

TJO/tb
Enclosures

Mailing Address:
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Raleigh, NC 27627

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[1]Licensed in NY/NJ

Exhibit Q

MYERS BIGEL SIBLEY & SAJOVEC, P.A.

PATENT LAWYERS

Jarett K. Abramson	Robert N. Crouse	Mary L. Miller, Ph.D.*[2]	Grant J. Scott
D. Randal Ayers	Robert W. Glatz	D. Scott Moore	Kenneth D. Sibley
David D. Beatty	Scott C. Hatfield	James D. Myers	Elizabeth A. Stanek
Mitchell S. Bigel	Devin R. Jensen	Timothy J. O'Sullivan	Richard P. Vitek
Needham J. Boddie, II	Laura M. Kelley	David K. Purks	Karen L. Wade, Ph.D.*[3]
Lynne A. Borchers*[1]	Shawna C. Lemon, Ph.D.	Julie H. Richardson	
James R. Cannon	Karen A. Magri, Ph.D.	Rohan G. Sabapathypillai	
Anna R. Carr	Robert M. Meeks	F. Michael Sajovec	

December 12, 2003

[redacted]
Cree, Inc.
4600 Silicon Drive
Durham, North Carolina 27703

Re: • *Non-Uniform Gate Pitch Semiconductor Devices*
Cree Docket No.: P0376; Our File: 5308-376

Dea[redacted]

The above-referenced patent application was filed in the United States Patent and Trademark Office by the express mail procedure today and should receive this date as the official filing date. We have enclosed a copy of this application and the accompanying documents as filed for your records. We also have enclosed a diskette containing the application in Microsoft Word format.

We will keep you advised of correspondence from the Patent Office regarding this application.

Best regards.

Sincerely,

Timothy J. O'Sullivan

TJO/tb
Enclosures

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